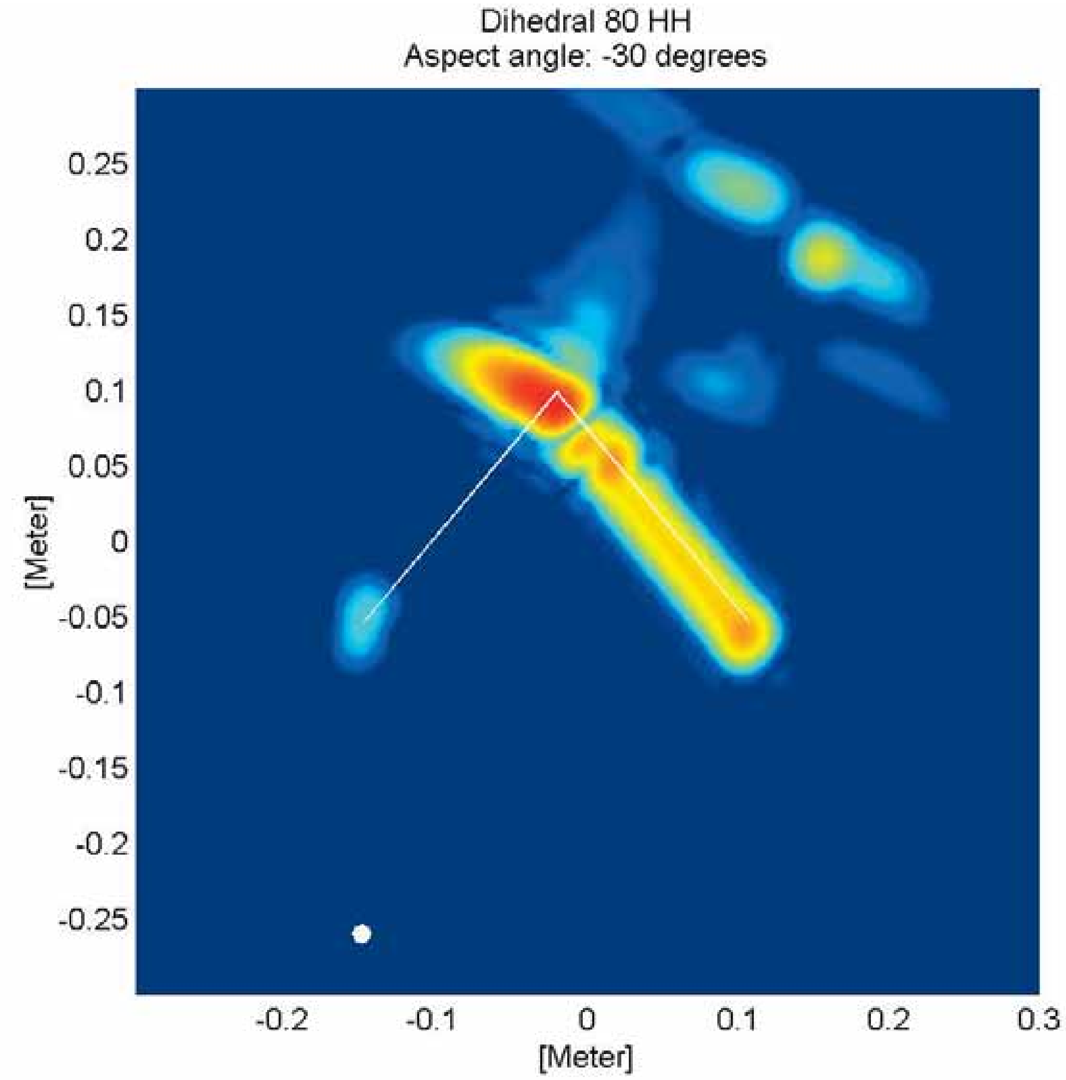
Radar hot spots from dihedral corner reflectors

JONAS RAHM, TORLEIF MARTIN, OLOF LUNDÉN



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FOI
Defence Research Agency
Sensor Technology
P.O. Box 1165
SE-581 11 Linköping

Phone: +46 13 37 80 00
Fax: +46 13 37 81 00

www.foi.se

Jonas Rahm, Torleif Martin, Olof Lundén

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Report title Radar hot spots from dihedral corner reflectors		
Abstract RCS measurements on dihedral corner reflectors have been conducted in the large anechoic chamber located at FOI in Linköping. The results have been used to generate ISAR images. The images exhibit hot spots that are located behind the dihedrals. The question is: what is the origin of those hot spots? This report will present ISAR-images of the 80º, 90º and 100º dihedrals. In addition the report presents a short analysis of the images with some scattering phenomena explanations of what can be the cause of the origin hot spots.		
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Rapportens titel

Radarspridningscentra från dihedraler

Sammanfattning

RCS mätningar har utförts på hörnreflektorer (dihedraler) i FOIs strora mäthall som är lokaliserad i Linköping. Resultaten har används till att generera ISAR avbildningar. Avbildningarna uppvisar spridningscentra som är lokaliserade bakom dihedralerna och frågan har varit hur dessa har uppkommit. Denna rapport presenterar ISAR-avbildningar för hörnreflektorerna 80º, 90º och 100º. Dessutom görs en kort analys av ISAR-avbildningarna med förklaringar på spridningsfenomen som kan ge orsaken till de uppkomna spridningscentra.

Nyckelord

RCS, Radarmålarea, RCS mätningar, Dihedraler

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Contents

Introduction

The objective of WP1.1 in the JP 1.18 CEPA project "Target and Target Background Modelling and Validation for High Resolution Radar" [1] is to compare the results from existing codes. The purpose is to test the capability of the codes to calculate multibounce reflections (dihedral case, task 1). In addition, measurements and MoM calculations were made to compare the high frequency results [2].

From these exercises we found some unexpected ISAR hot spots from the measurement data. This report will present some ISAR-images of the 80º, 90º and 100º dihedrals from measurement data and in addition present a more thorough study of the images. We do now believe that we partly have found explanations for those spots. The measurements were conducted in FOIs anechoic chamber [3] in Linköping. This report will only focus on some ISAR image results from these measurements. To get more information about the measurement procedure the reader is requested to apply for information from the authors of this report.

Measurement parameters

Object:	Dihedral corner reflectors consisting of two quadratic PEC plates, see figure 1. The edges of the plates are slanted.
Dimensions:	The height and width of the plates are 0.2 m. The dihedral angles, α, are 80º, 90º and 100º, see figure 1 and 2.
Calibration object:	Sphere (diameter = 0.3 meter)
Dielectric parameters:	PEC (all objects)
Frequency:	6 – 16 GHz in 401 steps => 0.025 GHz/step.
Polarisation:	HH and VV, where V (vertical) is parallel and H (horizontal) is perpendicular to the plane of incidence, see figure 2. H and V represent the E-field direction.
Elevation angle:	90º, i.e. in the plane perpendicular to the dihedral axis.
Azimuth angles:	From -60º to 60º in 121 steps => 1º/step
Measurement distance:	25 meters
Filtering:	Coherent background subtraction and 0-doppler filtering.
ISAR resolutions:	Down-range resolution ~ 1.5 cm. The cross-range resolution ~ 1.5 cm => the azimuth angular ISAR sector of about ± 28º.

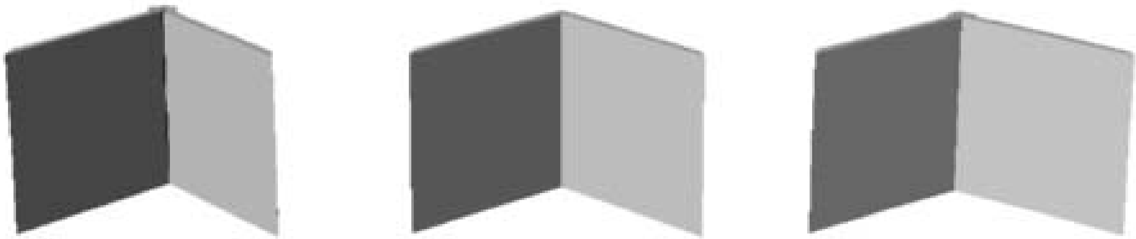

Figure 1. The CAD models of the 80º, 90º and 100º dihedral corner reflectors.

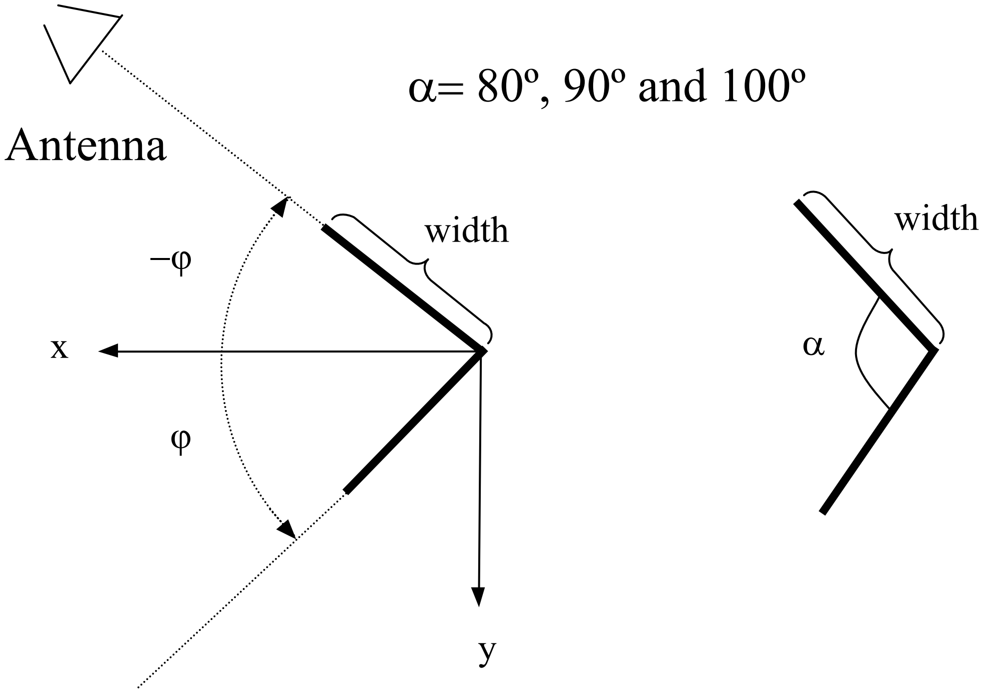

Figure 2. A schematic overview of the measurement setup.

ISAR-images

Figure 3 shows the ISAR images for the 80º, 90º and 100º. The images in the right column correspond to VV polarization and to the left HH polarization. The azimuth angle is -30º (according to the angle definition in figure 2) with an aperture angular range of ± 28º. All the images have been filtered by a Hanning window.

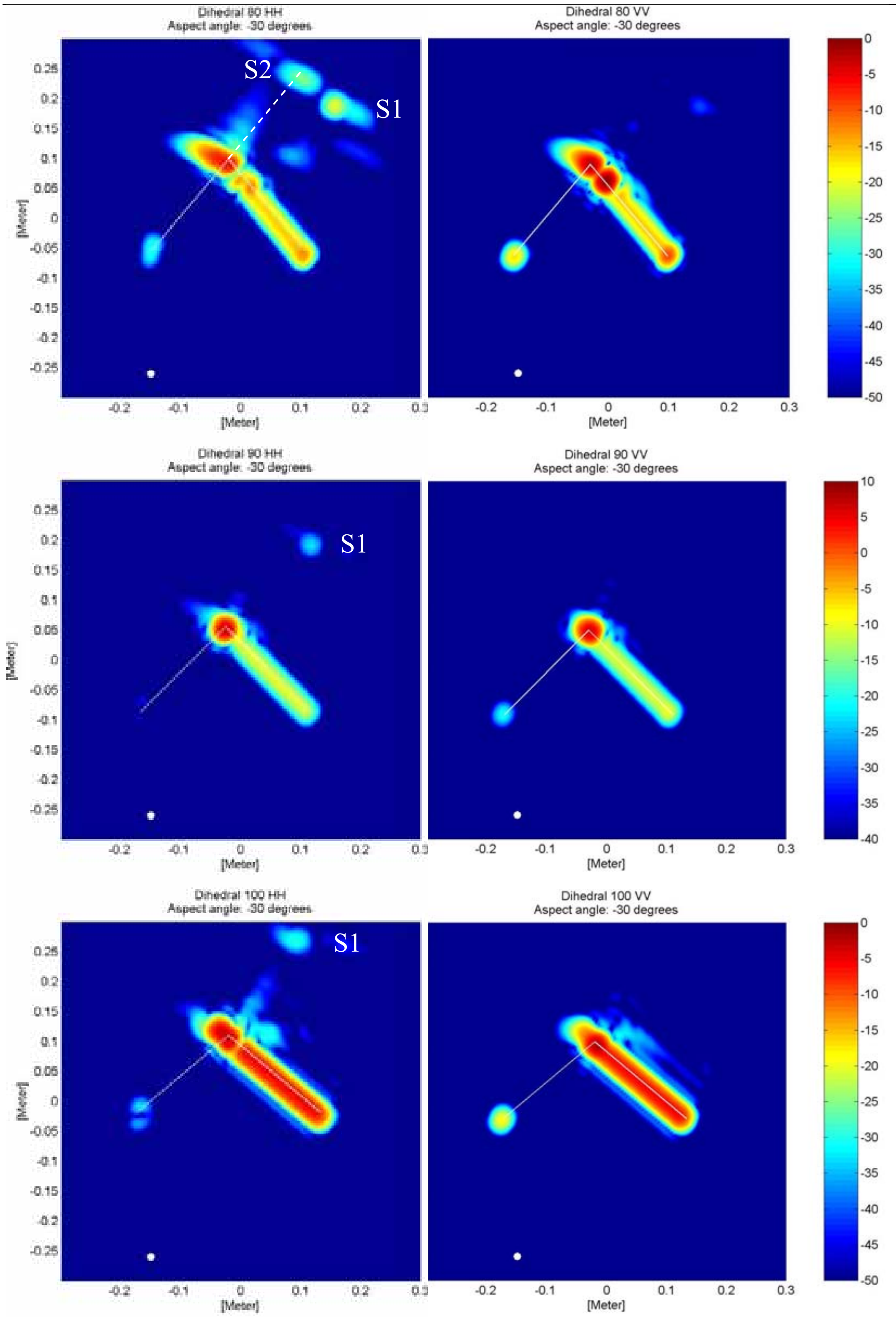

Figure 3. ISAR images of the 80º, 90º and 100º dihedral corner reflectors at HH- and VV-polarisations. The ISAR aperture is ±28º. The white dot represents the position of the antenna (in this case -30º according to the angle definition in figure 1). For guidance an overlay of the dihedrals has been placed over the images.

Analysis

For simplicity we will use ray tracing (illustrated by arrows) combined with diffraction (illustrated by circles) to try to explain the origin of the hot spots that occur in the ISAR images shown in the figures above.

The first observation that can be made in figure 3 is that the ISAR images exhibit a relatively strong polarization dependency. The ISAR spots labeled S1 and S2 are absent for the VV polarization case. This is due to the strong/dominating edge diffraction when the E-field is perpendicular to the edge.

In the HH polarization case the images for the 80º dihedrals exhibit two separate spots (labeled S1 and S2) located at about 0.20 – 0.25 meter on the y-axis and 0.10 – 0.15 meter on the x-axis in the ISAR local coordinate system (see figure above).

The origin of spot S1 is due to specular reflection from plate A to plate B according to figures 4 and 5. The edge of plate B will diffract the wave. The diffracted wave is, in a first approximation, homogeneously scattered in the xy-plane. Part of the diffracted wave will be scattered back to plate B and from there back to the original incident direction, i.e. the antenna direction. Such path will generate an ISAR spot located as a mirror image of the plate B edge. The mirror plane is in this case plate A. This is in good agreement with the measured ISAR images. All the dihedrals exhibit such mirror spots which is reasonable.

The origin of the ISAR spot S2 (see the top left ISAR image in figure 3) is not fully understandable. By using ray tracing consideration it can be shown that for dihedrals with an angle α less than 90º, it is possible to have two specular reflections before the EM wave is diffracted or reflected by other means. However, this is only valid for part of the aspect angle φ. For the 80º case it is valid for φ = -40º to -20º and +20º to +40º. In these regions it is possible to have two specular reflections. From image editing, see figure 6, it turns out that the S1 spot has its maximum at φ =-26º which is well in agreement with the scattering path illustrated in figure 4. S2 has its maximum at φ =-24º and occurs only in the 80º dihedral HH-polarisation case. The 90º and 100º images do not exhibit such spots. With these pieces of information it is easy to believe that the S2 spot originates from two specular bounces + diffraction + two specular reflections back (see right illustration in figure 4). However, the position of the ISAR spot for such a scattering path will not coincide with the spot seen in the measured ISAR image. Thus, the origin of the S2 spot is still unknown.

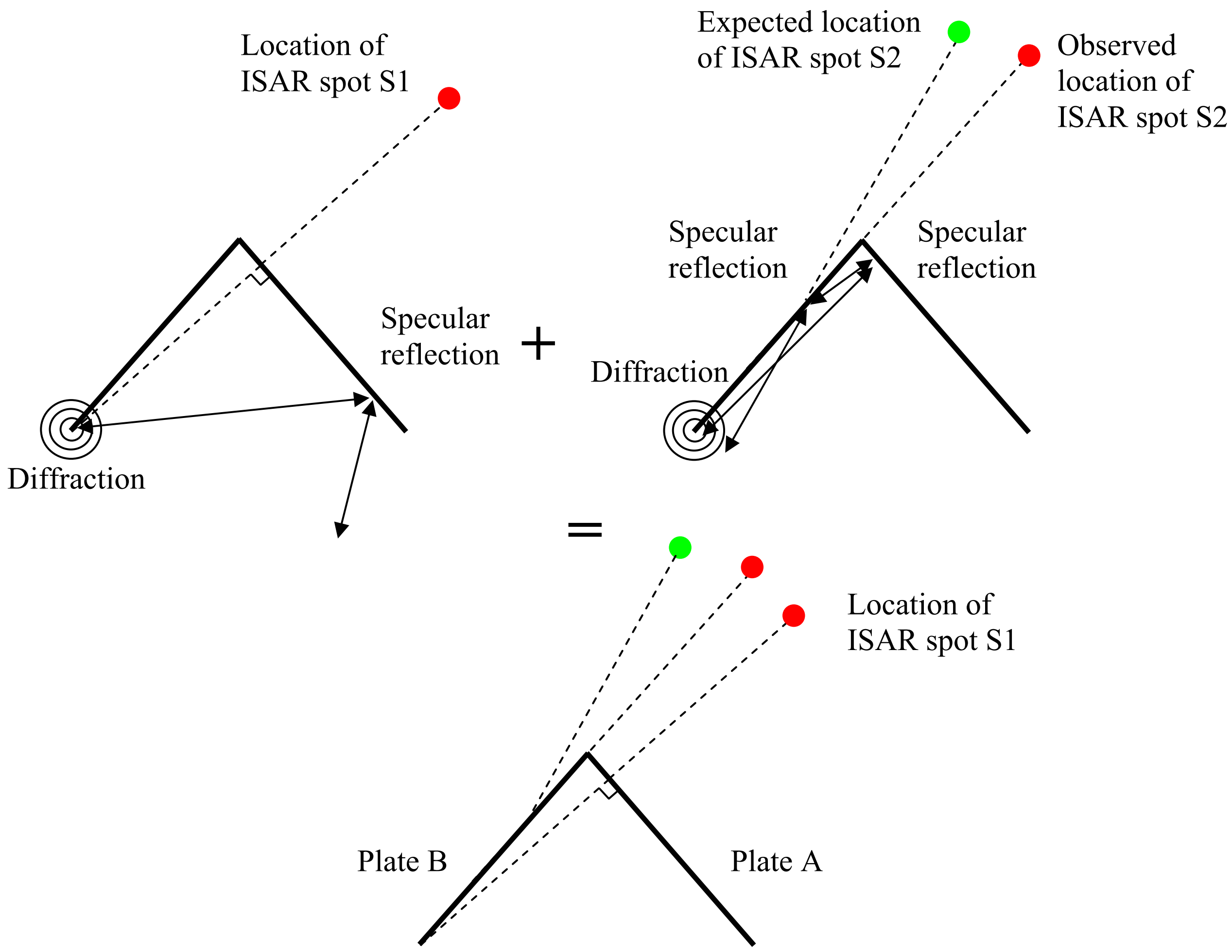

Figure 4. Schematic overview of the 80° dihedral. The arrows represent possible paths (rays) that generate ISAR spots according to the ISAR image for the HH-polarization case, see figure 3.

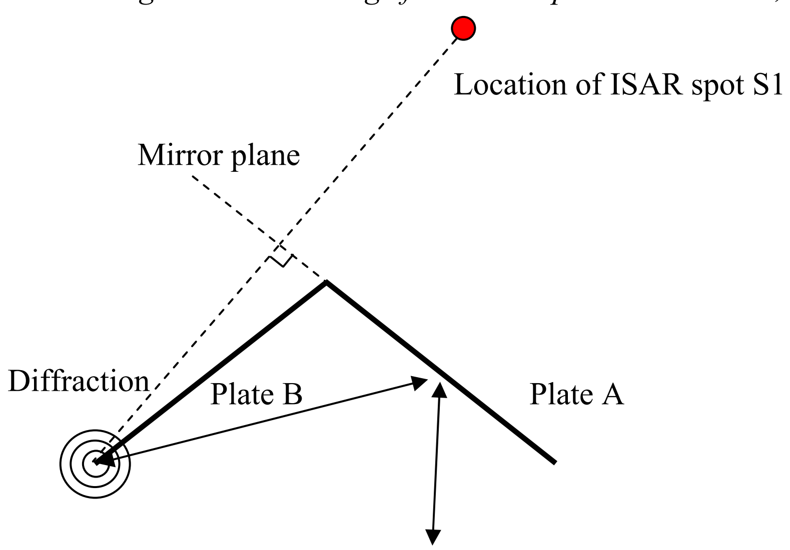

Figure 5. A schematic overview of the 100° dihedral corner reflector together with scattering paths (here represented by arrows and circles). The origin of the ISAR hot spots behind the dihedral corner reflector can be explained by specular reflection (plate A) – diffraction (plate B) – specular reflection (plate A).

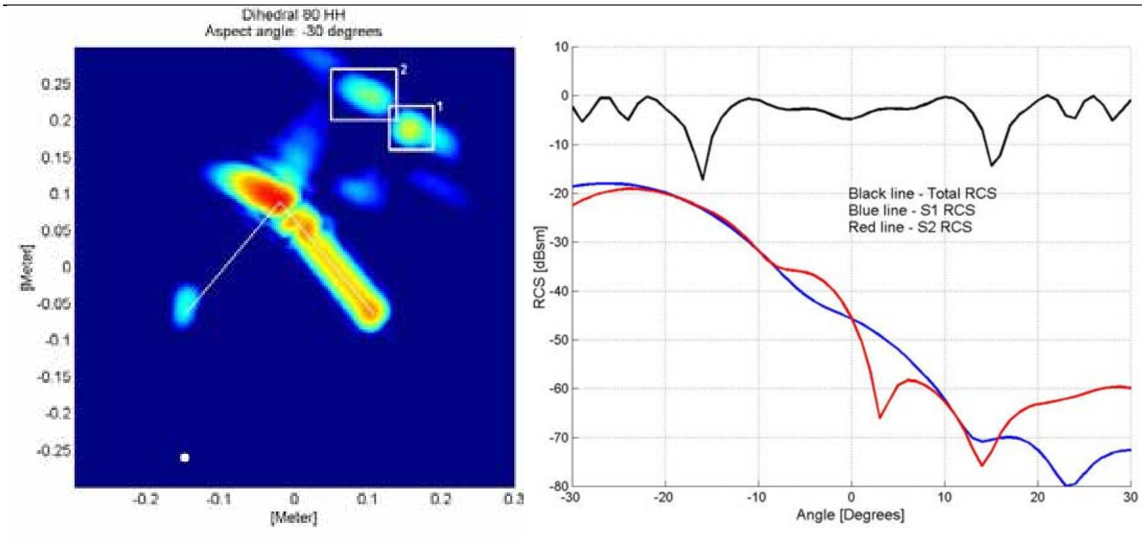

Figure 6. Left figure is showing the ISAR image of the 80º dihedral case at HH-polarisation. The ISAR data within the frames, labeled 1 and 2 in the figure, have been converted to RCS data. The right figure shows the result of that conversion, in this case RCS vs azimuth angle at 10 GHz.

References

[1] Supplement no JP1.18 “Target and Target Background Modelling and Validation for High Resolution Radar”, FOI ref no 02-2973, Linköping July 2002.

[2] “Test of existing codes”, editor Jonas Rahm, FOI Memo 829, Linköping February 2004.

[3] Olof Lundén, “Mätsystem i Stora Mäthallen”, FOA-D--00-00508-408--SE, Linköping December 2000.